UDC 666.3.022.4-182.2

FLUIDITY OF CLAY SUSPENSIONS FOR FACING TILES

I. V. Pishch,[1] E. P. Shishakov,[1] L. Yu. Malitskaya,[1] and O. I. Fedorova[1]

Translated from Steklo i Keramika, No. 12, pp. 15 – 17, December, 2004.

The effect of water glass with different silica moduli on the properties of slips is investigated. It is found that as the silica modulus increases, the efficiency of water glass as a liquefying agent grows. It is demonstrated that water glass – sodium tripolyphosphate and water glass – sodium polyacrylate as complex electrolytes are more efficient than each electrolyte separately. The highest drying rate is observed in the slip containing sodium polyacrylate and the lowest rate in the slip with sodium tripolyphosphate.

The production of ceramic tiles uses suspensions (slips) which after thermal dehydration yield molding powders for molding products.

According to the accepted technology, such slips are prepared by joint or separate moist grinding of the initial components: plastic, grog, and flux ingredients. Such slips are characterized by a particular moisture content, density, fluidity, ability for thixotropic thickening, stability, and dispersion of solid phase particles [1]. Moisture is removed from slips by thermal dehydration in tower spraying kilns. This drying process requires high heat and energy consumption. For instance, 3.0 – 3.5 kg of conventional fuel is spent to remove 1 kg moisture [2]. The consumption of heat and electricity directly depends on the initial moisture of slip delivered to the kiln. Therefore, to save fuel, one needs a slip that has the minimum possible moisture and yet preserves its flow properties. Moisture can be reduced by introducing traditional electrolytes, such as soluble water glass, soda, sodium tripolyphosphate, a coal-alkali reactant, etc. It is also possible to use slip thinners produced on the basis of synthetic polymers [3]. The mechanism of inorganic electrolytes and organic thinners is described in sufficient detail in [4].

Raw materials used for the production of wall facing tiles include low-melting, high-melting, and refractory clays. In particular, slip mixtures contain clays from the Novoraiskoe (Ukraine) and Gaidukovka (Belarus) deposit in a ratio of 3 : 2. These clays differ in their mineralogical and chemical compositions, degree of dispersion, and content of impurities, which has an effect on the moisture and liquescence of the slip.

In experiments, water glass of different silica modulus values, sodium tripolyphosphate and sodium polyacrylate, etc. were introduced into the slip. The content of electrolytes varied within the limits of 0.1 – 0.6% of dry clay weight. The liquefying effect of organic deflocculants is due to the fact that they are adsorbed on the surface of mineral particles and impart a negative charge to them. As a consequent of adsorption, protective hydrophobic colloids may be formed on the surface of clay particles, which decreases the solvation energy of these particles.

A separate introduction of water glass and sodium tripolyphosphate into the slip composition modifies flow properties in different ways. A wider thinning interval is achieved by introducing sodium tripolyphosphate, whereas the introduction of 0.4% water glass leads to the thickening (coagulation) of the clay – water system. In order to identify the mechanism of deflocculation by means of water glass, the effect of the silica modulus ($SiO_2 : Na_2O$) on the viscosity of the clay suspension was studied. For this purpose water glass with a silica modulus equal to 1.0, 2.6, and 2.8 was introduced into a slip of moisture 40%. The thinning and pH curves of clay suspensions are indicated in Fig. 1, which shows that the viscosity and pH of the slip decrease as the silica modulus increases, and the amount of electrolyte required to reach the maximum viscosity decreases as well (curves *1* and *3*). The results obtained show that a slip can liquefy more effectively using water glass with a higher silica modulus.

The introduction of traditional electrolytes in the form of water glass – sodium tripolyphosphate and water glass – soda combinations achieves different degrees of thinning. It is seen in Fig. 2 that a lowest viscosity is registered in the slip with 0.3% water glass additive. However, the liquefying interval with this electrolyte is narrow. A wider thinning interval with a conventional viscosity of 3.5 – 3.7°CV is obtained upon introducing water glass – sodium tripolyphosphate combined electrolyte and a less effective deflocculation upon adding water glass and soda.

In our opinion, the thinning effect is achieved not only due to Na^+ cations but also due to polyphosphate and

[1] Belarus State Technological University, Minsk, Belarus.

0361-7610/04/1112-0410

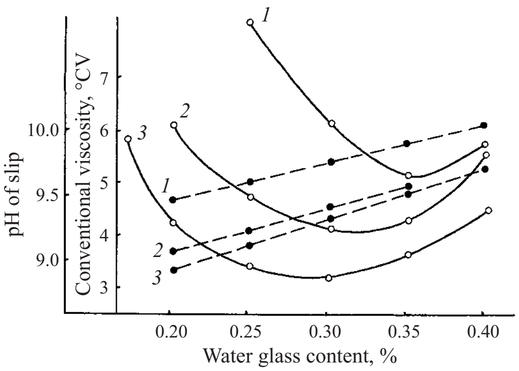

Fig. 1. The effect of water glass with silica modulus 1.0 (*1*), 2.6 (*2*), and 2.8 (*3*) on slip viscosity (solid curves) and pH (dashed curves).

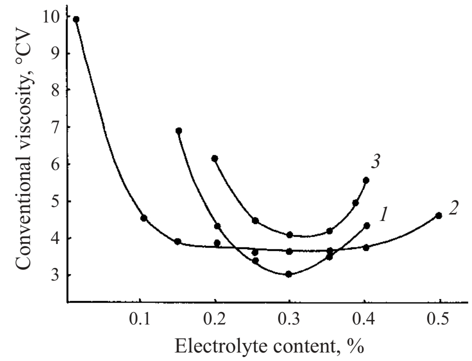

Fig. 2. The effect of water glass (*1*), sodium tripolyphosphate with water glass (*2*), and water glass with soda (*3*) on viscosity of slip with initial moisture 40%.

polysilicate anions which are adsorbed on the surface of the clay particles and impart a negative charge to them. As a consequence, the particles are repulsed and the water – clay system is maintained in a disperse state while preserving the structural-rheological parameters: yield point, thickening coefficient, and viscosity. The moisture of slip in using a mixture of electrolytes decreases by 3 – 5%. This is corroborated in measuring the flow properties of suspension with moisture 33.3 and 31.0% (Fig. 3*a*). With a suspension moisture equal to 33.3% the minimum conventional viscosity is 1.5°CV. In introducing sodium tripolyphosphate combined with water glass with modulus 2.8 the thickening coefficient is within the limits of 1.20 – 1.45 and pH = 8.7 – 9.7. With a slip moisture of 31.0%, the minimum viscosity of 2.1°CV is achieved when the electrolyte mixture is introduced in an amount of 0.2%. The thickening coefficient in this case is equal to 1.3. As the electrolyte content grows, the pH of the slip grows from 8.9 to 9.8.

Some companies producing ceramic tiles use not only tap water of varying hardness but also recirculating water containing up to 6.5% mineral inclusions. We established that the greater the mineral particle content in the recirculating water, the higher the parameters of electrolyte consumption and the least the moisture content in the slip. This also corroborates the assumption of the effect of water hardness on the consumption of electrolytes [5].

Therefore, to obtain a slip with the minimal moisture while preserving its structural-rheological parameters, we recommend using water of minimum hardness without suspended particles, which will decrease the unit consumption of fuel and energy and raise the efficiency of tower spraying kilns.

We investigated the effect of a nontraditional liquefier (sodium polyacrylate) on the flow properties of slip. As sodium tripolyphosphate is a scarce and expensive component, we used a combined additive of water glass – sodium polyacrylate. It was found (Fig. 3*b*) that the minimum viscosity and a wide thinning interval are registered in slip with moisture 33.3%. The thickening coefficient in this case is insignificant and equal to 0.9 – 1.1 The application of complex

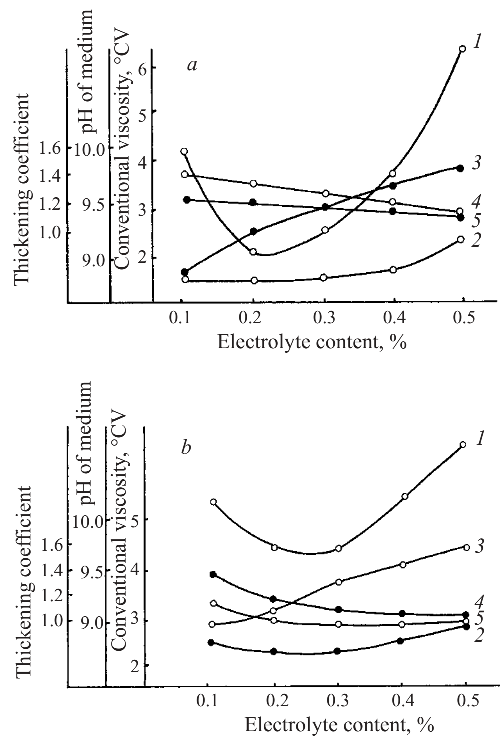

Fig. 3. The effect of complex electrolytes: water glass – sodium tripolyphosphate in ratio 1 : 1 (*a*) and water glass – sodium polyacrylate in ratio 1 : 1 (*b*) on viscosity (*1*, *2*), pH (*3*), and thickening coefficients (*4*, *5*) of slip with moisture 31.0% (*1*, *4*) and 33.3% (*2*, *5*).

electrolytes makes it possible to lower the moisture of slips and expand the thinning interval. A positive property of the sodium polyacrylate – water glass complex electrolyte is the insignificant variation of the pH of the suspension.

It was essential to investigate the slip drying process depending on the electrolyte introduced, since thermal dehydration takes place at the final stage of molding powder production. The rate of moisture removal from a clay suspension of moisture 39.4% was determined by the dynamic weighing

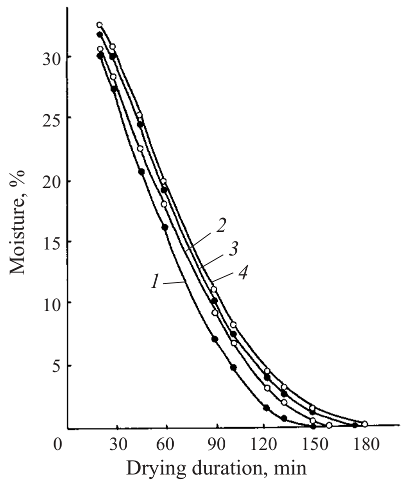

Fig. 4. Slip moisture variation depending on drying duration: *1*) sodium polyacrylate; *2*) water glass; *3*) sodium tripolyphosphate – water glass; *4*) sodium tripolyphosphate.

method based on the slip weight variation. The drying temperature was 100 ± 0.5°C. It can be seen from Fig. 4 that the most intense water release is registered in the slip containing sodium polyacrylate. In using this electrolyte, moisture is completely removed in 140 min. This is corroborated by the deflocculation mechanism of sodium polyacrylate ionized in an aqueous solution, whose anions are adsorbed on the surface of clay particles. In the drying of these particles moisture is removed from the surface more easily and the drying process accelerates. The process of water removal is hardest in slips containing sodium tripolyphosphate, where full drying is achieved in 180 min.

Thus, to decrease the moisture of ceramic slips used in tile production, it is recommended to use water of hardness not more than 6 – 7 mg · equ/dm^3 and complex electrolytes represented by sodium tripolyphosphate – water glass or polyacrylate – water glass (silica modulus over 2.6). This makes is possible to lower the slip moisture as much as possible while preserving its flow properties and, consequently, to reduce the unit consumption of fuel and electricity in making molding powder for the production of wall-facing ceramic tiles.

REFERENCES

1. *New Technology for Ceramic Tiles* [in Russian], Stroiizdat, Moscow (1977).
2. I. I. Moroz, *Technology of Porcelain and Faience Products* [in Russian], Stroiizdat, Moscow (1984).
3. M. K. Gal'perina, "Studies in the sphere of argillaceous material performed at NIIstroikeramika Institute," in: *Publ. of NIIstroikeramika Institute, Issue 34* [in Russian], Moscow (1971), pp. 72 – 87.
4. M. K. Gal'perina and N. V. Kolyshkina, "A study of rheological properties of argillaceous slips," in: *Publ. of NIIstroikeramika Institute, Issue 53* [in Russian], Moscow (1983), pp. 5 – 16.
5. N. S. Yugai and E. V. Klimova, "Flow properties of majolica slip with a liquefying additive based on sodium polyacrylate," *Steklo Keram.*, No. 1, 19 – 21 (2004).